Flow Around A Thin Profile With A Two-Phase Medium With Solid Particles

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Abstract

This article examines the problem of the effect of particles on a wedge. The structure of shock waves of a two-Phase Current is studied and the trajectory of particles is determined after the impact.

A flow model around a thin profile is proposed by a two-phase medium, taking into account the effect of reflecting particles from a solid surface. The problem is solved in a linear formula under different assumptions. Calculations are made for the initial parameters, and the results are presented graphically.

Keywords: supersonic current, barotronic medium, solid particle, elastic effect on the surface, nozzles, gas-dust environment, shock wave, wedge, jet, mirror reflection, thin profile, Laplace conversion, motion equation.

Access.

The problem of supersonic flow around the profile by the barotropic medium with solid particles is of practical importance when calculating the reactive parameters flowing from the supersonic nozzle, the flight of bodies in the gas-dust environment, etc., taking into account their elastic collision with the profile surface. The authors [1.2] considered the problem of the effect of particles on a wedge of not very large size. They studied the structure of the shock waves of a two-phase current and determined the trajectory of the particles before hitting the wedge, thereby not taking into account the reflective effect of the particles after the impact.

In this article, we propose a model for a thin profile flow by a two-phase medium, taking into account the effect of reflecting particles from the profile surface, and in addition, we will solve some problems. it is occupied by friction between particles and phases in a linear formula with various assumptions about size.

The main part.

Allow the two-phase current to flow around the thin profile. In this case, the limit condition imposed on the gas rate does not differ from the ideal Continuous Ambient Flow State, that is, for the gas rate, the flow state on the profile surface is satisfied. For particle speeds, such a boundary condition is not met, since it has a normal component for a solid surface, and the flow of particles is not provided by their reflection. The second phenomenon is reflected, that is, it serves as the basis for the appearance of the third current. In this case, a three-speed field of movement appears next to the body, lies between the body and the shock wave and is limited by a line (dividing line) slightly from the two-speed flow area. The geometric shape of the dividing line depends on many factors, for example, the nature of the particles and the surface of the body, the accepted model of movement, the law of reflection of particles, etc. [3] based on, we will only consider the law of specular reflection of particles from a solid surface.

Methodology.

Let the angle of inclination of the pona β_0 be given and it is required to determine the phase separation curve, that is, the current line of the particle reflected from the leading edge of the pona.Consider the case when the volume of carbon occupied by particles is small compared to one. At the same time, we assume that the effect of particles on gas pressure and the friction between the phenomenon and the reflected particles in the three-speed current region can be neglected. Then, based on the linear theory of wedge flow [4], the gas velocity field is known and the gas velocity potential of the words is expressed by formula φ_1

$$\varphi_1(x, y) = -\frac{U_0\beta_0}{\mu}(x - \mu y) \qquad (1.1)$$

where $\mu^2 = M^2 - 1$; $M = U_0/a$; $U_0 -$ is the initial speed of a two - phase Medium; a is the speed of sound in a gas.

The only force acting on the particles is the friction force between the phases. Therefore, once the equation is linear, the movement of incoming and reflected particles takes shape:

$$U_0\frac{\partial u_2}{\partial x} = \frac{k}{\rho_2}(u_1 - u_2), \qquad U_0\frac{\partial v_2}{\partial x} = \frac{k}{\rho_2}(v_1 - v_2); \qquad (1.2)$$

$$U_0\frac{\partial u_3}{\partial x} = \frac{k}{\rho_2}(u_1 - u_3), \qquad U_0\frac{\partial v_3}{\partial x} = \frac{k}{\rho_2}(v_1 - v_3). \qquad (1.3)$$

In addition $\rho_2 = \rho_{2i}(1 - \gamma_0)$; $\rho_{2i} -$ the actual density of the particle; γ_0– the volumetric concentration of the gas in the unit of volume; the coefficient of interaction of the phases determined by I – Stokes; u_1, v_1, u_2, v_2, u_3и v_3 - the components of the speed of the reflected flow Although (1.2) and (1.3) are formally identical, their boundary conditions are completely different. If we enter the speed potential φ_2 into the equations (1.2) and multiply the first by dx and the second by dy, then after assembling them we get an equation at full differentials.The Integral of this equation contains an arbitrary constant equal to zero from Infinite conditions.

So the equations (1.2) and (1.3) will be:

$$\varphi_{2x} - \alpha(\varphi_1 - \varphi_2) = 0, \qquad \varphi_{3x} - \alpha(\varphi_1 - \varphi_3) = 0 \qquad (1.4)$$

where $\alpha = \frac{K}{U_0 P_2}$; φ_1 is determined by the formula (1.1).Note that the (1.4) system is equal to (1.2) and (1.3) systems.

The boundary conditions are as follows:

$$\varphi_2 = 0 \ \text{ to } \ x - \mu y = 0, \qquad (1.5)$$

$$\varphi_{3y} = U_0\beta(x) \ \text{ to } \ y = f(x), \qquad (1.6)$$

$$2U_0\beta_0 = \varphi_{2y} + \varphi_{3y} \ \text{ to } \ y = 0, \qquad (1.7)$$

Where $y = f(x)$ – is the equation; $\beta(x) -$ is the angle of inclination of the Section line. (1.7) the condition is the law of reflection of particles from the surface of the wedge (the angle of incidence is equal to the angle of reflection). Let's say a section line is also a straight line with an unknown angle of inclination β, which is determined later (1.7) from the condition. Then (1.6) is written:

$$\varphi_{3y} = U_0\beta \ \text{ to } \ y = \beta \cdot x. \qquad (1.8)$$

Solutions that satisfy (1.5) and (1.8), equations (1.4) are obtained in the form of squares, that is

$$\varphi_2(x, y) = \frac{U_0\beta_0}{\alpha\mu}\left[1 - \alpha \cdot (x - \mu y) - \exp\left(-\alpha(x - \mu y)\right)\right] \qquad (1.9)$$

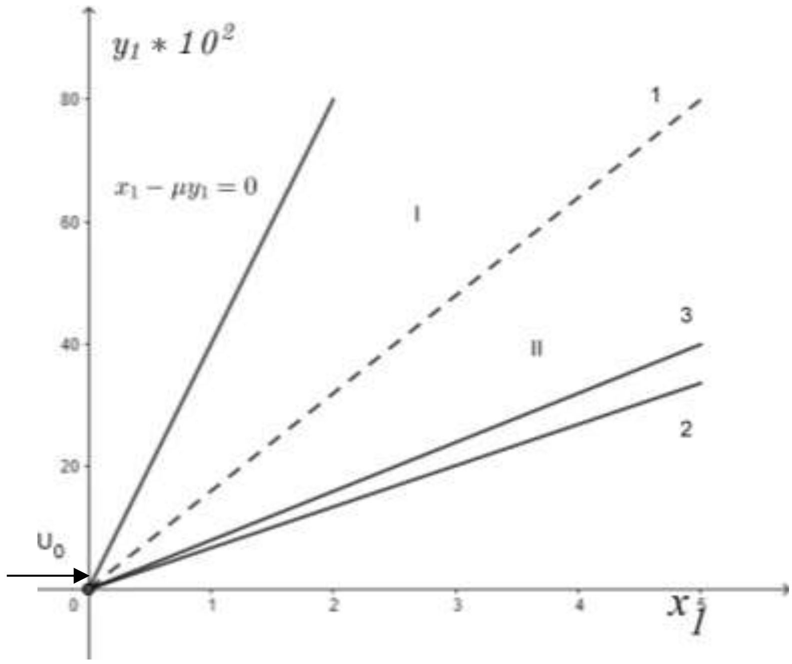
$$\varphi_3(x, y) = -\frac{U_0}{\alpha}\left[\frac{\beta_0}{\mu} + \beta(\beta - \beta_0)\right] \cdot \exp(-\alpha x) +$$

$$+\frac{U_0}{\alpha}\left\{\frac{\beta_0}{\mu}[1 - \alpha(x - \mu y)] + \beta(\beta - \beta_0) \cdot \exp\left(-\frac{\alpha}{\beta}(\beta \cdot x - y)\right)\right\} \qquad (1.10)$$

After receiving (1.10), the condition $\varphi_{3x} = 0$ for $x = y = 0$ is also satisfied. Replacing (1.9) , (1.10) and (1.7), it is easy to determine that $\beta = 2\beta_0$.

In the same way, solving the inverse problem, we get similar results, since here the Section line is fixed in the form of a straight line, and the surface of the simplified body is searched for.

From this we can conclude that if the volume occupied by the particles is insignificant, then when the particles of a two-phase current hit the wedge, the dividing line (the flow line of particles reflected from the leading edge) will also be correct with an angle of inclination twice the angle of the wedge half-solution(See Photo).



Ini of Section 1; Profile Surface; 2 – small and 3-with a significant concentration of particles.

§ 2. Some studies on the winding of bodies with a two-phase particle medium with a large concentration of particles

Discussions.

If the current has a lot of solid particles, then the interaction of phases must be taken into account. In the general formula, it is difficult to solve this problem without using numerical methods. Therefore, it is proposed to solve a special case in which the effect of the reflected current on the flow of a two-phase medium is neglected. In this case, the Section line is only the reflected flow line, that is, the third stream. In the work [5], based on [3], the equations of the two-phase medium are given in simple form, in which case they have the form:

$$\gamma_0\left[(M^2-1)\varphi_{1xx}-\varphi_{1yy}\right]-\frac{\rho_2}{\rho_{2i}}(\varphi_{2xx}+\varphi_{2yy})=-\frac{K}{U_0}\cdot\frac{M^2}{\rho_0}(\varphi_{2x}+\varphi_{2y}) \quad (2.1)$$

$$\frac{\rho_2}{\rho_{2i}}\rho_{10}\varphi_{1x}-\gamma_0\rho_2\varphi_{2x}=-\frac{K}{U_0}(\varphi_1-\varphi_2) \quad (2.2)$$

Where $\varphi_0=\frac{\rho_{10}}{\rho_0}$, the remaining characters are the same as §1.

Obviously, equations (2.1) and (2.2) are valid in areas I and II (See Figure). The equation of the third flow motion after linearization and transformation, as in §1, is as follows:

$$\varphi_{3x}+\alpha\varphi_3=\alpha\varphi_1(x,y) \quad (2.3)$$

Writing (2.3) did not take into account the direct action of solid particles of incoming flow and the effect of gas through the pressure gradient [6] of the unreflected flow. Consider the flow of bodies with a two-phase current in the reverse setting, that is, we consider that a section line with a constant angle of inclination β is given, and determine the surface area of the simplified profile.To solve this problem, we write the boundary conditions:

$$\varphi_{1y}=U_0\beta_1(x) \;\; to \;\; y=0, \quad (2.4)$$

$$\varphi_{3y}=U_0\beta \;\; to \;\; y=\beta\cdot x, \quad (2.5)$$

$$2U_0\beta_1(x)=\varphi_{2y}+\varphi_{2y} \;\; to \;\; y=0. \quad (2.6)$$

In addition to,

$$\varphi_1=\varphi_2=0 \;\; to \;\; x-\mu y=0, \;\; \varphi_{3x}=0 \;\; to \;\; x=y=0 \quad (2.7)$$

Where $\beta_1(x)-$ is the angle of the thin profile. Referring to systems (2.1) and (2.2), The Laplace Transform [7] taking into account the variable x and the condition (2.4), the formulas for the speed potentials φ_1 and φ_2 are not given here. From the formula for φ_2 we have $y=0$

$$\varphi_{2y}=U_0\left[\frac{\rho_0}{\rho_{2i}}\beta_1(x)+\alpha_1\left(1-\frac{\rho_0}{\rho_{2i}}\right)exp(-\alpha_1 x)\int_0^x\beta_1(\tau)\cdot exp(\alpha_1\tau)\,d\tau\right] \quad (2.8)$$

where $\alpha_1 = \alpha/\gamma_0$; ρ_0 - is the actual density of the gas. Equation (2.3) provides a solution taking into account (2.5) and (2.7)

$$\varphi_3(x,y) = -\frac{U_0\beta^2}{\alpha}\cdot exp(-\alpha x) +$$

$$+\left\{\frac{U_0\beta^2}{\alpha}\cdot exp\left(\frac{\alpha}{\beta}-y\right) - \alpha\int_0^y\left[\int_0^x \varphi_{1y}\cdot exp(\alpha x)\,dx\right]_{x=\frac{y}{\beta}} dy\right\} exp\,(-\alpha x) +$$

$$+\alpha\cdot exp(-\alpha x)\cdot\int_0^x \varphi_1(x,y)\cdot exp(2x)\,dx \qquad (2.9)$$

Therefore, differentiating with y, we have $y = 0$

$$\varphi_{3y} = U_0\left[\beta + \alpha\int_0^x \beta_1(\varepsilon)\cdot exp(\alpha\varepsilon)\,d\tau\right] exp(-\alpha x) \qquad (2.10)$$

Replace (2.8) and (2.10) to (2.6), smelly

$$\left(2-\frac{\rho_0}{\rho_{2i}}\right)\beta_1(x) = \beta\cdot exp(-\alpha x) + \alpha\cdot exp(\alpha x)\int_0^x \beta_1(\tau)\cdot exp(\alpha\tau)\,d\tau +$$

$$+\alpha_1\left(1-\frac{\rho_0}{\rho_{2i}}\right)\cdot exp(-\alpha_1 x)\cdot\int_0^x \beta_1(\tau)\cdot exp(\alpha_1\tau)\,d\tau. \qquad (2.11)$$

Next, applying the Laplace conversion [7] and moving to the original, from (2.11) we get this

$$\beta_1(x) = \frac{\beta}{1+\gamma_0\left(1-\frac{\rho_0}{\rho_{2i}}\right)}\cdot$$

$$\cdot\left[1 - \frac{(1-\gamma_0)\left(1-\frac{\rho_0}{\rho_{2i}}\right)}{2-\frac{\rho_0}{\rho_{2i}}} exp\left(-\frac{\alpha_1+\alpha\left(1-\frac{\rho_0}{\rho_{2i}}\right)}{2-\frac{\rho_0}{\rho_{2i}}}\right)\right]. \qquad (2.12)$$

If $\frac{\rho_0}{\rho_{2i}} \ll 1$, then from (2.12) we have

$$\beta_1(x) = \frac{\beta}{1+\gamma_0}\left[1-\frac{1-\gamma_0}{2} exp\left(-\frac{\alpha_1+\alpha}{2}x\right)\right]; \qquad (2.13)$$

Obviously, $\frac{dy}{dx} = \beta_1(x)$. Therefore, the inclusion of dimensionless variables combining $\frac{\alpha_1+\alpha}{2}x = x_1$, $\frac{\alpha_1+\alpha}{2}y = y_1$ and (2.13), we find the profile surface equation as follows

$$y_1 = \frac{\beta}{1+\gamma_0}\left[x_1 - \frac{1-\gamma_0}{2}(1-\exp(-x_1))\right]. \qquad (2.14)$$

Conclusions.

Now, using (2.13) and (2.14), it is possible to obtain the calculated formulas of the speed field and the pressure in the squares.

Thus, a simplified profile surface with a two-phase medium with a significant concentration of solid particles, taking into account their mirror reflection, is a curve slightly bent in relation to the current, in contrast to the results of §I. with an increase in x_1, the three-speed Region II gradually narrows.

According to the above method,calculations are made for the initial parameters $\beta = \frac{\pi}{18}$, $M = 2, \gamma_0 = 0{,}9$ and the results are graphically given (see Figure).

Literature

1. H. A. Rahmatulin. Fundamentals of gas dynamics of interpenetrating movements of a compressed medium. Pmm, 20, no.2, 1956.
2. N. A. Mamadaliyev. About the movement of bodies at a speed higher than sound in a two-component environment. Izv. Academy of Sciences of the uzssr, a number of technologies. Sciences, 1966 No. 1.
3. R. I. Nigmatulin. The degree of hydromechanics and compression waves in a two-speed and two-temperature constant medium in the presence of phase changes. Izv 1967 No. 5.
4. T. A. Djalilova. Rapid leakage of a thin wedge and cone sound with a gas flow with particles, taking into account heat exchange and particle reflection. Academician of Sciences of Izvestia SSR, series of technical sciences, 1976, No. 3, article.

5. T. A. Djalilova. Dissertation on the topic:"the study of the flow of flat and excimetric bodies with a gas flow with solid particles, taking into account the heat exchange between phases and the reflection of particles from the solid surface." 01.02.02-fluid, gas and plasma mechanics. 24. 10. 1978 year.

6. T. A. Djalilova, G. Sh. Komolova, M. D. Khalilov. On the distribution of the spherical wave V. innovative, educational, natural and Social Sciences. 87-92 page 16. 03. 2022 year.

7. T. A. Jalilova, K.Atabaev, S.Khakimov. ((2021) heavy-duty flow around a thin keel and a cone of then gas with particles with the participation of heat exchange and reflection of particles. NAMANGANISHTECHNIKA SCIENTIFIC AND TECHNICAL INSTITUTE JOURNAL, 301-305.

8. S.Khakimov solve issues related to the power of the engine. (2022) SCIENTIFIC AND TECHNICAL JOURNAL OF ANDIJAN INSTITUTE OF MECHANICAL ENGINEERING, 214-219.

9. Durbek o‘g‘li, X. M., & Tulqinovna, S. M. (2023/1/1). ODDIY DIFFERENSIAL TENGLAMALARNI MEHANIKA VA FIZIKANING BAZI MASALALARINI YECHISHGA TADBIQLARI. Новости образования: исследование в XXI веке (стр. 763-773). Rossiya: Международный научный журнал .

10. Xalilov M., Komolova G., Komiljonov B. Solve some chemical reactions using equations // European Journal of Business Startups and Open Society. Vol. 2 No. 1 (2022): EJBSOS ISSN: 2795-9228. 45-48 p.

11. M.D. Xalilov, B.K. Komiljonov, G.Sh. Komolova. Garmonik skalyar tebranishlarning kompleks va vektor ifodalanishi. Miasto Przyszłości. ISSN-L:2544- 980X. Table of Content - Volume 24 (Jun 2022).

12. Murodiljon, K., Gulhayo, K., & Bobur, K. (2022). Solve some chemical reactions using equations. European Journal of Business Startups and Open Society, 2(1), 45-48.

13. Джалилова, Т. А., Комолова, Г. Ш. К., & Халилов, М. Д. У. (2022). О РАСПРОСТРАНЕНИИ СФЕРИЧЕСКОЙ ВОЛНЫ В НЕЛИНЕЙНО-СЖИМАЕМОЙ И УПРУГОПЛАСТИЧЕСКОЙ СРЕДАХ. Oriental renaissance: Innovative, educational, natural and social sciences, 2(3), 87-92..

14. Комолова, Г., & Халилов, М. Stages of drawing up a mathematical model of the economic issue. Journal of ethics anddiversity in international communication. Испания-2022, 60, 45-48.

15. Xalilov, M. D., Komiljonov, B. K., & Komolova, G. S. (2022). COMPLEX AND VECTOR EXPRESSION OF HARMONIC SCALIAR VIBRATIONS. Miasto Przyszłości, 24, 341-344.

16. Xalilov, M. D., & Komiljonov, B. K. (2022). Komolova GS GARMONIK SKALİAR VIBRASYONLARNING KOMPLEKSI VA VEKTOR FOYDALANISHI. Miasto Przyszłości, 341-344.

17. Gulhayo, K. G. K., Murodil, X., & Bobur, K. Ba’zi kimyoviy reaksiyalarni tenglamalar yordamida yechish. EVROPA JURNALI, 45-48.

18. Komolova, G., Xalilov, M., & Komiljonov, B. Tenglamalar yordamida ba’zi kimyoviy reaksiyalarni yechish. Yevropa biznes startaplari va ochiq jamiyat jurnali.-2022.-2-jild.-Yo'q, 1.

19. Djalilova, T., Komolova, G., & Xalilov, M. (2022). О распространении сферической волны в нелинейно-сжимаемой и упругопластической средах. Oriental Renaissance: Innovative, educational, natural and social sciences jurnali, 2181-1784.

20. Komolova, G. (2022). Stages of drawing up a mathematical model of the economic issue. journal of ethics and diversity in international communication, 1(8), 76-79.

21. Komolova, G., Khalilov, M., & Komiljonov, B. (2022). Solve Some Chemical Reactions Using Equations. European Journal of Business Startups and Open Society, 2(1).

22. Комолова, Г. ХМ (2022.). Комолова Гулхаё, Халилов Муродил, Комилжоноа Бобур,“Solve some chemical reactions using equations”. EUROPEAN JOURNAL OF BUSINESS STARTUPS AND OPEN SOCIETY, 2(1), 45-48.